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Inventor(s) or Application Identifier
Noriaki YUKAWA, Hajime KAWANO, and Yukihiro AYAKITitle: METHOD OF ERASING REPEATED PATTERNS AND
PATTERN DEFECT INSPECTION DEVICE

ADDRESS TO:

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APPLICATION ELEMENTS

ACCOMPANYING APPLICATION PARTS

1. ☒ Fee Transmittal Form
2. ☒ Specification [Total Pages 16]
(preferred arrangement set forth below)
- Descriptive title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R & D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings (if filed)
- Detailed Description
- Claim(s)
- Abstract of the Disclosure
3. ☒ Drawing(s) (35 USC 113) [Total Sheets 6]
- ☒ Oath or Declaration [Total Pages 4]
- a. ☒ Newly executed (original or copy) ☐ Unexecuted
- b. ☐ Copy from a prior application (37 CFR 1.63(d))
(for continuation/divisional with Box 18 completed)
[Note Box 5 below]
- i. ☐ **DELETION OF INVENTOR(S)**
Signed statement attached deleting inventor(s)
named in the prior application, see 37 CFR 1.63(d)(2)
and 1.33(b).
5. ☐ Incorporation By Reference (useable if Box 4b is checked)
The entire disclosure of the prior application, from which a copy
of the oath or declaration is supplied under Box 4b, is considered
as being part of the disclosure of the accompanying application
and is hereby incorporated by reference therein.
6. ☐ Microfiche Computer Program (Appendix)
- Nucleotide and/or Amino Acid Sequence Submission
(if applicable, all necessary)
- a. ☐ Computer Readable Copy
- b. ☐ Paper Copy
- c. ☐ Statement verifying identity of above copies

8. ☒ Assignment Papers (cover sheet & document(s))
9. ☐ 37 CFR 3.73(b) Statement (when there is an assignee) ☐ Power of Attorney
10. ☐ English Translation Document (if applicable)
11. ☐ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
12. ☐ Preliminary Amendment
13. ☒ Return Receipt Postcard (MPEP 503)
(Should be specifically itemized)
14. ☐ Small Entity Statement(s) ☐ Statement filed in prior application,
Status still proper and desired
15. ☐ The prior application is assigned of record to _____
16. ☒ Foreign priority claimed
- a. ☒ Claim of Priority
- b. ☒ Certified Copy of Priority Document(s)
17. ☐ Other: _____

18. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior Application No. _____ / _____, filed _____.19. ☐ Amend the specification by inserting before the first line the sentence:

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METHOD OF ERASING REPEATED PATTERNS AND
PATTERN DEFECT INSPECTION DEVICE

BACKGROUND OF THE INVENTION

5 1. TECHNICAL FIELD OF THE INVENTION

The present invention relates to a method of erasing repeated patterns and to a pattern defect detection device in image processing when detecting pattern defects contained in electronic equipment devices such as liquid crystal panels, plasma display panels, or semiconductor wafers.

2. DESCRIPTION OF RELATED ART

Conventionally, inspection of pattern defects in the manufacture of electronic equipment devices such as liquid crystal panels, plasma or display panels or semiconductor wafers was performed by visual inspection by human beings or by automatic image processing carried out by machine.

In the case of visual inspection, alterations in the type of electronic equipment being inspected can easily be coped with, and start-up is rapid, but there are the drawbacks that identifying the precise positions of defects takes time and throughput is poor. Maintaining and standardizing detection sensitivity is also a problem.

In contrast, in the case of image processing using a machine, although there are the advantages that rapid identification of the precise positions of defects and

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maintenance and standardization of the detection sensitivity can be achieved, there was the problem that considerable time was required for adjustment in the event of alterations in the type of electronic equipment being manufactured.

5 With increases in the structural fineness and performance of components in recent years, the poor throughput of visual inspection has become increasingly prominent. There are therefore considerable expectations in regard to improvement of performance of machines that
10 perform image processing.

 However, although the structural fineness and performance of electronic equipment devices such as liquid crystal panels, plasma or display panels and semiconductor wafers has considerably increased, these devices are often
15 formed with a large number of repeated patterns identical to a partial pattern. To detect defects in such repeated patterns, conventionally, processing was performed as follows.

 Firstly, pattern erasure is performed as described
20 below by performing the processing:

$$g_{out} = g_{in} - g(in + size) + offset$$

 on all the pixels of the raw image, including the imaged repetition pattern, that are within the processing region, with the standard pitch of the repetition pattern.

25 Here, g_{out} is the density of the pixels of the image after

51, 52 respectively on the raw image prior to pattern processing and the image after processing. The direction of increased brightness is the direction of approach to gradation number 255; the direction of decreasing brightness is the direction approaching gradation 0. Whether or not the pattern has been erased after processing can be ascertained by comparing the density profiles 53 and 54.

Defect detection processing consists detecting as a defect satisfaction of certain density conditions in the image after processing illustrated in Figure 5B. Taking as an example the density profile 54 on check line 52, if a density gradation of more than the specific density gradation 135 is deemed to constitute a white defect and a density gradation of less than specific density gradation of 120 is deemed to constitute a black defect, 55 is detected as a black defect.

However, in the above conventional pattern erasure processing, there are the following three problems.

Firstly, normal portions of the pattern are left in the background image.

Secondly, although they might originally be white defects or black defects, when both white defects and black defects occur in the background image, it becomes difficult to distinguish which kind of defects they originally were.

Thirdly, processing of the peripheral pattern cannot be performed normally.

These are now described in detail below.

The first problem does not arise if the pattern pitch
5 is an integer at all locations. However, it is impossible
for the pitch to be the same over the entire raw image.
This is because, when image pickup is effected through a
large number of lenses employed for image input, due to the
effects of lens aberration, image pickup cannot be effected
10 at exactly the same pitch in the center and periphery of the
lenses. Also, it is difficult to make this an integer value
with no error at all. Examples are the residual portions 58
and 59 of Figure 5B.

The second problem is a phenomenon that may occur due
15 to comparison before and after. The white defect 56 in the
middle of the processing region 50 of Figure 5A appears as
defect portions 56 and 57 in Figure 5B which are of higher
density and lower density than the background density. The
distance between pixel 56 and pixel 57 is of course the size
20 of the pattern erasure processing. It is therefore
impossible to tell simply from an individual defect portion,
whether the original defect was a white defect or a black
defect.

The third problem, like the second problem is a
25 phenomenon that may occur due to comparison before and after.

When pattern erasure processing is performed over the entire input image, as shown in Figure 6A and Figure 6B, a region 60 corresponding to the size of the pattern erasure processing on the right hand side of the region cannot be
5 obtained as a result of normal processing. This is because there are no comparison pixels.

SUMMARY OF THE INVENTION

An object of the present invention is to solve the
10 above problems and to provide a method of erasing repeated patterns in which inspection of defects in a repeated pattern can be performed without problems.

A method of erasing repeated patterns according to the present invention comprises, in a dark/light image obtained
15 by image pickup of a subject of inspection, when identifying defects present in a repeated pattern in a subject of inspection, a step of detecting a plurality of density differences in which the density differences are found between reference pixels separated by values of a pre-
20 determined reference size and sizes which are integral multiples thereof and a plurality of comparison pixels, a step of determining a specific density difference wherein the density difference that is closest to 0 or the mean density difference from a plurality of density differences
25 is detected as specific density difference, and a pattern-

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erased image generation step in which the specific density
difference is applied to the reference density in the
pattern-erasure image; by detecting the specific density
differences using the density differences with respect to a
5 plurality of comparison pixels, the problems mentioned above
are eliminated and a repeated pattern can be suitably erased
without using a complicated algorithm.

Also, a pattern defect inspection device according to
the present invention comprises an image pickup element that
10 picks up an image of an inspection subject and a processing
device that detects pattern defects by storing and
processing dark/light image data obtained by image pickup of
the inspection subject wherein the processing device
comprises: a portion for detecting a plurality of density
15 differences in which the density differences are found
between reference pixels separated by a pre-determined
reference size and sizes which are integral multiples
thereof and a plurality of comparison pixels; a specific
density difference determining portion wherein the density
20 difference that is closest to 0 from a plurality of density
differences is detected, a pattern-erased image generation
portion in which the specific density difference is applied
to the reference density in the pattern-erasure image; and a
defect detection portion; thus the repeated pattern can be

erased and pattern defects detected in a suitable way as described above.

Other and further objects, features and advantages of the invention will appear more fully from the following
5 description.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a layout diagram of a pattern defect inspection device wherein an embodiment of a method of
10 erasing repeated patterns according to the present invention is applied;

Figure 2 is a processing flow chart of a repeated pattern erasure method according to the above embodiment;

Figure 3 is a diagram of filter elements in this
15 embodiment;

Figure 4A and Figure 4B are diagrams of images before and after processing in this embodiment;

Figure 5A and Figure 5B are diagrams of images before and after processing by a repeated pattern erasure method
20 according to a prior art example; and

Figure 6A and Figure 6B are diagrams of images before and after processing illustrating a region which is incapable of being processed in the prior art example.

25 DESCRIPTION OF PREFERRED EMBODIMENTS

An embodiment in which a repeated pattern erasure method and pattern defect inspection device according to the present invention are applied to inspection of an electrode wiring glass panel in a liquid crystal array panel is described below with reference to Figure 1 to Figure 4.

In Figure 1, which illustrates diagrammatically the construction of a pattern defect inspection device according to the present invention, the subject of inspection 1 is arranged in a prescribed position and is supplied with illumination by downward illumination 2, and an image thereof is picked up by an image pickup element comprising a CCD area sensor etc. The image data from the sensor pixels in image pickup element 3 is transferred, in one-to-one correspondence, to image memory 5 in a computer 4 constituting a processing device. The image data transferred into this image memory 5 is read to computer 4 and a processing program 6 is stored that performs prescribed processing. The image density is processed in 256 gradations, namely, 0 to 255.

Figure 2 shows the flow of processing of the method of detection of defects by repeated pattern erasure. In Figure 2, first of all, in image input step No. 1, the image data that is obtained from image pickup element 3 is stored in image memory 5 of computer 4. Next, in a plurality of density difference detection steps of step No. 2, the

following processing is performed with the size (21 pixels)
found beforehand from the pattern pitch. The density
differences between reference pixels and a plurality of
comparison pixels separated by a value of an integral
multiple of the aforesaid size are thereby found.

$$gout-n = gin - g (in+size*n) \quad \dots(1)$$

The reference pixels and comparison pixels are called
filter elements. Figure 3 shows the relationship of filter
elements at the positions of particular reference pixels.

Reference pixels 11, 12, 13, 14 are set up that are
separated by values of integral multiples of the size with
respect to reference pixel 10. Four density differences are
obtained by expression (1). These are designated gout-1,
gout-2, gout-3 and gout-4.

Next, in the specific density difference determination
step of step No. 3, the final output densities are
determined from the four density differences gout-1, gout-2,
gout-3, and gout-4 of expression (1). In the case where the
object is pattern erasure, the value of these values which
is closest to 0 is selected. For example, if gout-1 = 3,
gout-2 = -2, gout-3 = 10, and gout-4 = -9, gout-2 is
selected as the specific density difference.

Next, in the erased image generation step of step No. 4,
the specific density difference found in the specific
density difference determination step is added to the

reference density in the pattern erasure image. The
reference density is determined in the same way as the
offset described in the prior art example; in the case of
256 8-bit gradations of 0 to 255, the reference density will
5 often be gradation 128.

Figure 4A is an image which has a repeated elongated
pattern prior to pattern erasure processing and Figure 4B is
the image after processing. Even if processing is performed
on the entire input image area, the first to third problems
10 of the prior art example are solved. White defect 20 and
black defects 21, 22, 23, and 24 respectively appear in the
image after processing as an independent white defect and
independent black defects. Also, normal processing can be
performed over the entire area of the image and the pattern
15 can be reliably erased.

Although, in the description of the above embodiment,
in the step of determining the specific density difference,
the specific density difference that was closest to 0 was
selected, depending on the circumstances, the mean value of
20 a plurality of density differences could be selected as the
specific density difference.

Since, with the method of erasing repeated patterns and
pattern defect inspection device according to the present
invention, there are provided a step of detecting a
25 plurality of density differences in which the density

differences are found between reference pixels separated by the value of a reference size which was previously found as described above and values of integral multiples thereof and a plurality of comparison pixels, a step of determining a specific density difference wherein the density difference that is closest to 0 or the mean density difference is detected as specific density difference from a plurality of density differences, and a pattern-erased image generation step in which the specific density difference is applied to the reference image of the pattern-erasure image, the problems of the prior art are solved, and, without using a complicated algorithm, the repeated pattern can be suitably erased, making it possible to detect pattern defects.

Although the present invention has been fully described in connection with the preferred embodiment thereof, it is to be noted that various changes and modifications apparent to those skilled in the art are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.

CLAIMS

WHAT IS CLAIMED IS:

1. A method of erasing repeated patterns in a dark/light image obtained by image pickup of a subject of inspection, when identifying defects present in a repeated pattern in a subject of inspection, comprising the procedures of:

demarcating the obtained image into a plurality of areas;

10 detecting a reference pixel in one of said demarcated areas;

assigning a comparison pixel in each of the rest of said demarcated areas;

15 obtaining a plurality of density differences between said reference pixel and each of said comparison pixels;

determining a density difference that is closest to 0 as a specific density difference; and

applying said specific density difference to a reference density of the image.

20 2. The method of erasing repeated patterns in a dark/light image according to Claim 1, wherein the subject of inspection is a liquid crystal array panel.

3. The method of erasing repeated patterns in a dark/light image according to Claim 1, wherein the subject of inspection is a plasma display panel.

4. The method of erasing repeated patterns in a dark/light image according to Claim 1, wherein, in the step of demarcating the obtained image into a plurality of areas, the plurality of areas have a size of a predetermined number of pixels obtained in accordance with the pattern pitch of the repeated patterns in the dark/light image.

5. The method of erasing repeated patterns in a dark/light image according to Claim 1, wherein, in the step of determining a specific density difference, a mean value of the plurality of density differences between the reference pixel and the comparison pixels is determined as the specific density difference.

6. A method of manufacturing electronic equipment devices at least including liquid crystal panels, plasma display panels, and semiconductor wafers, including an inspection process that is performed in accordance with the method of erasing repeated patterns as set forth in claim 1.

7. A pattern defect inspection device comprising:
an image pickup element that picks up an image of a subject of inspection; and

a processing device that detects pattern defects by storing and processing dark/light image data obtained by image pickup of the inspection subject, wherein the processing device includes:

a unit for demarcating the obtained image into a plurality of areas,

detecting a reference pixel in one of said demarcated areas,

5 assigning a comparison pixel in each of the rest of said demarcated areas, and

obtaining a plurality of density differences between said reference pixel and each of said comparison pixels;

10 a unit for determining a density difference that is closest to 0 as a specific density difference; and

a unit for generating a pattern-erased image.

8. The pattern defect inspection device according to Claim 7, wherein the subject of inspection is a liquid crystal array panel.

15 9. The pattern defect inspection device according to Claim 7, wherein the subject of inspection is a plasma display panel.

10. The pattern defect inspection device according to Claim 7, wherein, instead of determining a density difference that is closed to 0 as a specific density difference, a mean value of the plurality of density differences between the reference pixel and the comparison pixels is determined as the specific density difference.

ABSTRACT OF THE DISCLOSURE

An image of a subject of inspection is picked up, and this image is demarcated into a plurality of areas. Density differences are found between reference pixels and a plurality of comparison pixels in the demarcated areas, and a density difference that is closest to 0 is determined as a specific density difference. The specific density difference is then applied to the reference density in the image of the subject, whereby repeated patterns in the image are erased.

Fig. 1

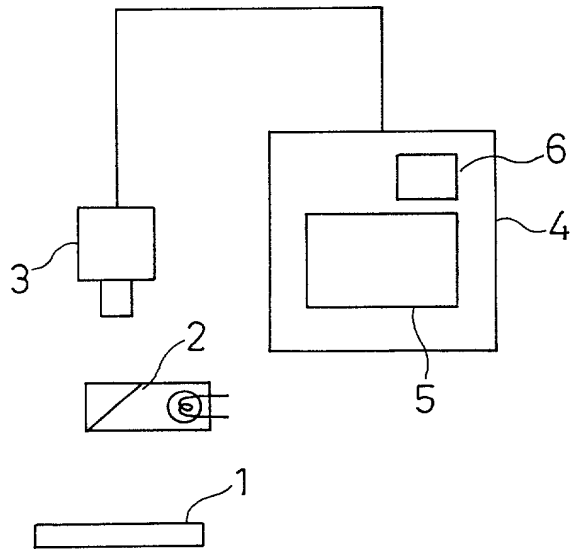
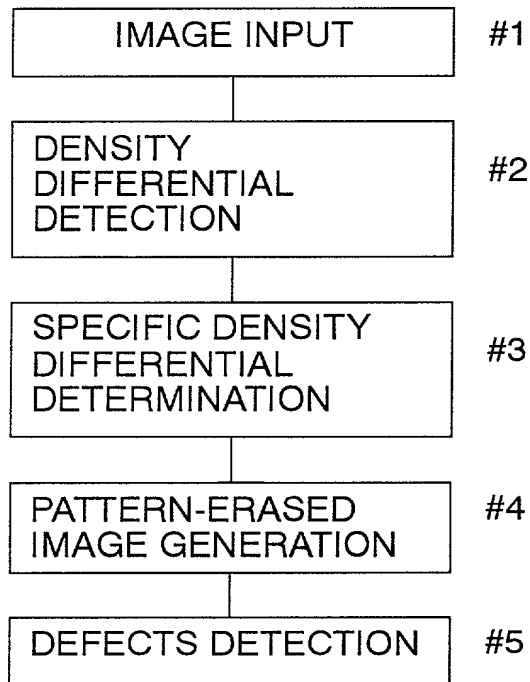


Fig. 2



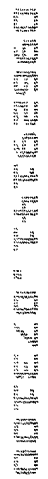
[illegible]

Fig. 4 A

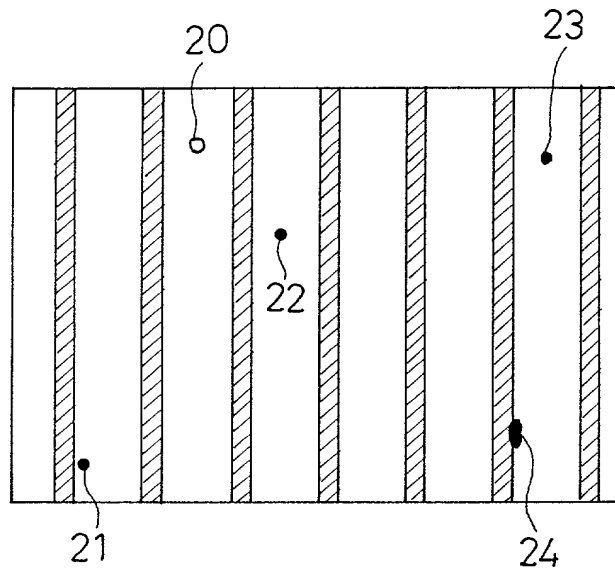


Fig. 4 B

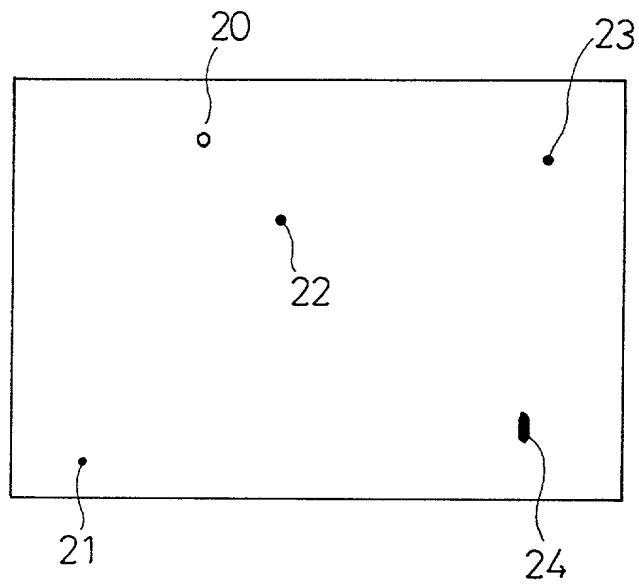


Fig. 5A
Prior Art

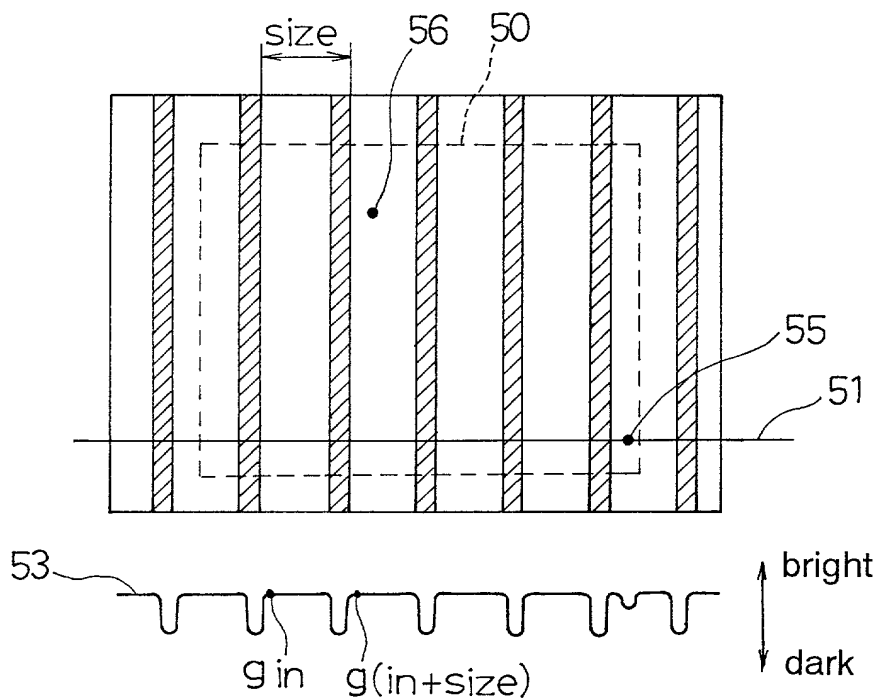


Fig. 5B
Prior Art

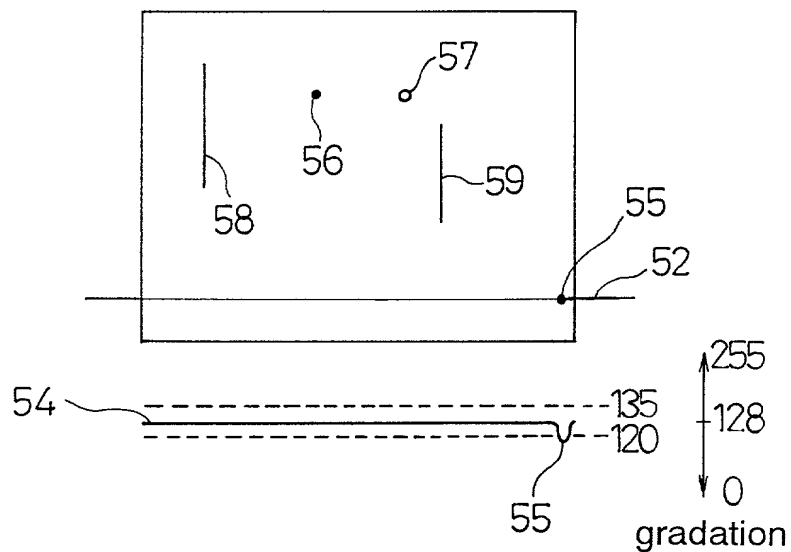


Fig. 6 A
Prior Art

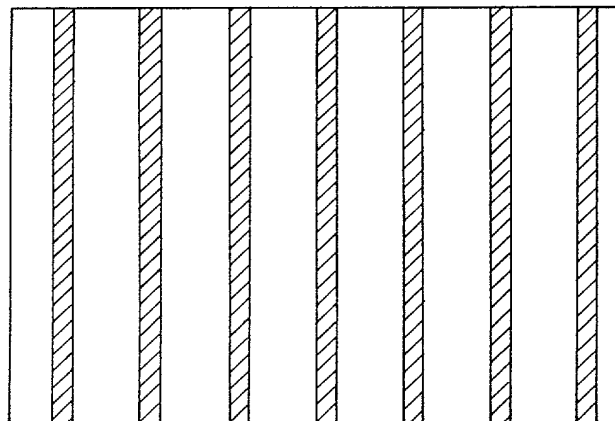
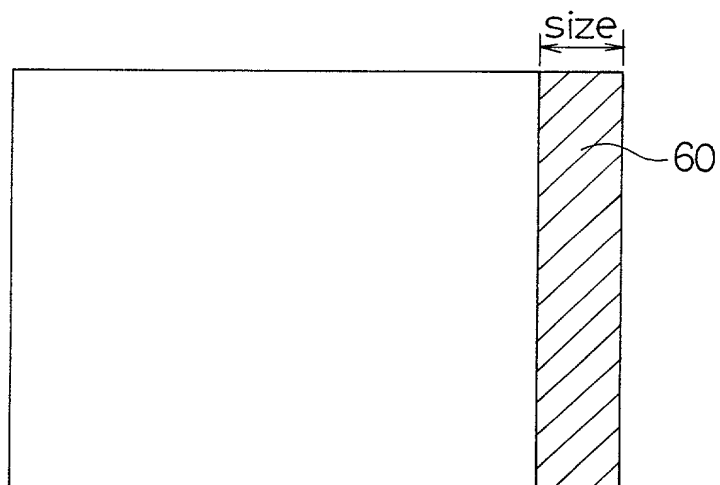


Fig. 6 B
Prior Art



Declaration and Power of Attorney For Utility or Design Patent Application

特許出願宣言書

Japanese Language Declaration

私は、下欄に氏名を記載した発明者として、以下のとおり
宣言する：

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下欄に記載されている場合)と信じ、

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated
below next to my name.

I believe I am the original, first and sole inventor (if only one name is
listed below) or an original, first and joint inventor (if plural names
are listed below) of the subject matter which is claimed and for
which a patent is sought on the invention entitled

"Method of Erasing Repeated Patterns
and Pattern Defect Inspection Device"

the specification of which is attached hereto unless the following
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☐ was filed on _____ as

United States Application Number _____

and was amended on _____ (if applicable) or,

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I hereby state that I have reviewed and understand the contents
of the above identified specification, including the claims, as
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I acknowledge the duty to disclose information which is material to
patentability as defined in Title 37, Code of Federal Regulations,
§1.56.

I hereby claim foreign priority under Title 35, United States Code
§119(a-d) or §365(b) of any foreign application(s) for patent or
inventor's certificate, or §365(a) of any PCT international application
which designated at least one country other than the United States,
listed below. I have also identified below, by checking the "No"
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any PCT international application having a filing date before that of
the application on which priority is claimed:

Priority claimed

優先権の主張

☒ ☐

Yes No

あり なし

☐ ☐

Yes No

あり なし

Prior foreign applications

先の外国出願

11-218606

Japan

02/08/1999

(Number)

(番号)

(Country)

(国名)

(Day/Month/Year Filed)

(出願の年月日)

(Number)

(番号)

(Country)

(国名)

(Day/Month/Year Filed)

(出願の年月日)

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☐ Additional foreign application numbers are listed on a
supplemental priority sheet attached hereto.

Japanese Language Utility or Design Patent Application Declaration

私は、合衆国法典第35部第119条(e)項に基づく、下記の合衆国仮特許出願の利益を主張する。

I hereby claim the benefit under Title 35, United States Code §119(e) of any United States provisional application(s) listed below.

(Application No.)
(出願番号)

(Day/Month/Year Filed)
出願の年月日

(Application No.)
(出願番号)

(Day/Month/Year Filed)
出願の年月日

(Application No.)
(出願番号)

(Day/Month/Year Filed)
出願の年月日

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I hereby claim the benefit under Title 35, United States Code §120 of any United States application(s), or §365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

(Application No.)
(出願番号)

(Day/Month/Year Filed)
(出願の年月日)

(現況)
(特許済み、係属中 放棄済み)

(Status)
(patented, pending, abandoned)

(Application No.)
(出願番号)

(Day/Month/Year Filed)
(出願の年月日)

(現況)
(特許済み、係属中 放棄済み)

(Status)
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Japanese Language Utility or Design Patent Application Declaration

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Bruce H. Bernstein
James L. Rowland
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POWER OF ATTORNEY: As a named inventor, I hereby appoint the attorney(s) and/or agent(s) associated with the Customer Number provided below to prosecute this application and transact all business in the Patent and Trademark Office connected therewith, and direct that all correspondence be addressed to that Customer Number:

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唯一のまたは第一の発明者の氏名	Full name of sole or first inventor
発明者の署名	Inventor's signature
住所	Residence
国籍	Citizenship
郵便の宛先	Post Office Address
第2の共同発明者の氏名 (該当する場合)	Full name of second joint inventor, if any
同第2共同発明者の署名	Second Inventor's signature
住所	Residence
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郵便の宛先	Post Office Address

(第六またはそれ以降の共同発明者に対しても同様な情報および署名を提供すること。)

(Supply similar information and signature for third and subsequent joint inventors.)

Japanese Language Utility or Design Patent Application Declaration

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第五の共同発明者の氏名	Full name of fifth inventor, if any
共同発明者の署名	Fifth Inventor's signature
住所	Residence
国籍	Citizenship
郵便の宛先	Post Office Address
第六の共同発明者の氏名	Full name of sixth inventor, if any
共同発明者の署名	Sixth Inventor's signature
住所	Residence
国籍	Citizenship
郵便の宛先	Post Office Address

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(Supply similar information and signature for subsequent joint
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